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ABSTRACT

This booklet, one of six in the Living Things Science series, presents activities about heredity and genetics which address basic "Benchmarks" suggested by the American Association for the Advancement of Science for the Living Environment for grades 3-5. Contents include background information, vocabulary (in English and Spanish), materials, procedures, extension activities, and worksheets. The worksheets are presented in both English and Spanish versions. Suggestions for use of the activities include using student grouping, a related readings center, and journal keeping. Activity names are: "Peas in a Pod," "Inherited or Learned," "Pass It On," "Population Sampling," "Corn Genes," "Codebreaker," "Alphabet Soup," "Super Sleuth," "DNA Fingerprints," and "Chimera." An appendix contains a list of people that have contributed to the fields of genetics and heredity, and lists of fiction and non-fiction readings. (MKR)

HEREDITY

GENERATION TO GENERATION

LIVING THINGS SCIENCE SERIES

INVITATIONS

TO

HEREDITY

Generation to Generation

Teacher-Friendly Science Activities

with reproducible handouts in English and Spanish

Grades 3-5

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Life's Diversity

Heredity: Generation to Generation

Cells: Life's Building Block

Interdependence: Caught in the Web

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INVITATION TO THE HEREDITY

Generation To Generation

CONCEPTS

- Some characteristics are inherited, some are not.
- There is a reliable way to transfer information from one generation to another.

INTRODUCTION

Heredity--the passing of characteristics from one generation to the next, is one of the processes carried on by all living things. All living things move, grow, change, ingest nutrients, reproduce, dispose of waste, breath and die. Because all living things eventually die, there needs to be a way for the species to survive. This process is called reproduction. Through the process of reproduction the characteristics of the parents are passed to the offspring.

Gregor Mendal (1822-1884), an Austrian monk and biologist, showed that patterns of heredity reflect the transmission of coded information from parents to offspring. This information is recorded on chromosomes. The word *chromosome* means body color. When stain was added to a cell, the chromosomes were seen as dark bodies, hence the name. Before the turn of the 20th century chromosomes were not thought to have any role in heredity.

Later Wilhelm Johannsen called the units of heredity *genes*. The gene is the part of the DNA molecule that carries the instructions for producing a specific trait like eye color. Different forms of the same trait are called alleles.

In 1879 Walther Flemming was the first person to observe chromosomes. Thirty years later Walter Sutton proposed that genes were located on the chromosomes.

Humans have 46 chromosomes in 23 pairs, in most cells. A typical chromosome contains thousands of genes.

Sometimes genes are damaged or copied incorrectly. These changes are called mutations. Mutations act as a source of variation that is needed for a species to adapt to changing conditions or a new environment.

The invitations in this book provide activities to address the basic *Benchmarks* suggested by the American Association for the Advancement of Science for the Living Environment for grades 3-5, Project 2061. Due to the nature of the interdependence of all things, some activities address aspects of one or more of these concepts and are highlighted by bold print in the concept section of each *Invitation*.

SCIENCE JOURNAL

Encourage students to keep journals of their observations and to reflect on these observations as they struggle with the concepts of *Heredity*. The students can create their own format for their science journals, the teacher can suggest a format or the reproducible pages at the end of this book may be used.

CLASSROOM MANAGEMENT

The activities in this *Invitation* can be managed in a variety of ways. However, students should have many opportunities to work together in groups of 3-4 students. By sharing and working together, students will be able to value their fellow students' contributions, as well as begin to realize that the

process that they are experiencing is similar to the work of scientists.

If it is possible in your classroom, identify one area, desk or table, as *Invitations to Heredity*. In this center include books from the resource list and extension activities.

Some aspects of these invitations are more appropriate for the younger students, while other aspects are better for older students. Teachers should feel free to adapt each activity for their particular students.

SPECIAL NOTE:

Some of the topics addressed in the study of heredity may be sensitive areas for children who are adopted or who are living in one parent or *blended* families. Statements such as, "You have blue eyes so both your parents probably have blue eyes," may lead to embarrassing moments if a blue eyed child has been adopted by brown eyed parents and doesn't know she/he is adopted.

Adoption, re-marriage, and artificial insemination contribute to the fact that the chances are that at least 50% of the children in classrooms in the United States are not living with both genetically related parents. This means that activities related to family genetics are becoming more and more difficult and those activities related to family trees may even be inappropriate.

RELATED READING FOR INVITATION CENTER

Aronson, Billy. *They Came From DNA*. New York: W. H. Freeman & Co., 1993.

Asimov, Isaac. *How Did We Find Out About Genes?* New York: Walker Books, 1983.

Backwill, Fran. *DNA Is Here To Stay*. Minneapolis: CarolRhoda, 1993.

Bial, Raymond. *Corn Belt Harvest*. Boston Houghton, 1991.

Bornstein, Sandy. *What Makes You What You Are: A First Look At Genetics*. New York: Julian Messner, 1989.

Brooks, Bruce. *Nature By Design*. New York: Farrar, 1991.

Dash, Joan. *The Triumph of Discovery: Women Scientists Who Won The Nobel Prize*. New Jersey: Dial Books for Young Readers, 1990.

Dunbar, Robert E. *Heredity, Heredity*. New York: Franklin Watts, Inc., 1978.

Fradin, Dennis. *Heredity*. Chicago: Children's Press, 1978.

Gutnik, Martin J. *Genetics*. New York: Franklin Watts, 1985.

Haldane, Suzanne. *Helping Hands: How Monkeys Assist People Who Are Disabled*. New York: Dutton Children's Books, 1991.

Jaspersohn, William. *Cranberries*. Boston: Houghton, 1991.

Kent, Charlotte. *Barbara McClintock*. New York: Chelsea House, 1991.

Lavies, Bianca. *Monarch Butterflies: Mysterious Travelers*. New York: Dutton Children's Books, 1993.

Patent, Dorothy Hinshow. *Grandfather's Nose: Why We Look Alike Or Different*. New York: Franklin Watts, 1989.

Rankin, Laura. *The Handmade Alphabet*. New York: Dial, 1991.

Ryden, Hope. *Your Dog's Wild Cousins*. New York: Lodestar, 1994.

Showers, Paul. *Me And My Family Tree*. New York: Thomas F. Crowell, 1978.

Watson, James. *The Double Helix*. New York: Atheneum, 1968.

VOCABULARY

The teacher is encouraged to help students develop their own unique set of vocabulary words depending on the student's interest, experience, and ability. The following words are primarily for the teacher.

adaptation: the process by which a species becomes better suited to its environment

cell: basic building block of all organisms

chromosome: a rod shaped structure within the cell nucleus composed of DNA

cytoplasm: protoplasmic material that lies outside the nucleus, but inside the cell membrane

daughter cells: newly formed cells which result when there is division of an existing "mother" cell. The offspring receive identical nuclear materials.

deoxyribonucleic acid: known as DNA a molecule that encodes information about heredity and makes up genetic material

dominant character: character that always shows in first generation offspring

evolution: the slow process by which organisms genetically change over time.

gene linkage: the linear arrangement of genes on a chromosome

gene pool: all the genes present in a given population

gene: basic unit of inheritance

genetic code: the sequential arrangement of the bases in the DNA molecule, which control traits of an organism

adaptación: el proceso por el cual las especies se acostumbran a su medio ambiente

célula: componente básico de todos los organismos

cromosoma: estructura de forma alargada la cual se encuentra dentro del núcleo celular y el cual está compuesto de DNA

citoplasma: material protoplásmico que se localiza fuera del núcleo y a la vez dentro de la membrana celular

células hijas: células que han sido formadas por la división de la célula madre y las cuales contiene el mismo material en su núcleo

ácido deoxiribonucleico: conocido como DNA, este ácido está compuesto por moléculas que almacenan información hereditaria y genera material genético

característica dominante: característica que se manifiesta siempre en la primera generación de un especimen dado

evolución: el proceso lento por el cual los organismos cambian genéticamente a través del tiempo

enlace genético: la agrupación lineal de genes en un cromosoma

combinación genética: todos los genes presentes en una población dada

gene: unidad básica de herencia

código genético: la organización en secuencia de bases en la molécula de DNA la cual controla las características de un organismo

genetics: the study of how traits are inherited

genética: el estudio de como las características fisicas son heredadas

genotype: the heredity makeup of an organism

genotipo: la configuración hereditaria de un organismo

heredity: the transmission of traits from one generation to the next.

herencia: la transmisión de características de una generación a una generación siguiente

hybrid: an offspring obtained by crossing parents which differ in one or more traits.

híbrido: una cria formada del cruce de sus progenitores y la cual difiere de estos en una o más características

hybridization: the crossing of different strains, varieties, or species to establish new genetic characteristics

hibridización: el cruce de diferentes grupos, variedades o especis para establecer nuevas características genéticas

incomplete dominance: a blend of two traits resulting from a cross of these characteristics

dominación incompleta: mezcla de dos características resultando del cruce de estas características

individual characteristics: traits that are inherited but which make organisms different from others of the same species.

características individuales: rasgos que son heredados pero que hacen organismos diferentes a otros de su misma especie

lethal gene: a gene that is potentially fatal to the organism

gene letal: un gene el cual es potencialmente fatal para el organismo

mass selection: the picking of ideal plants or animals to serve as parents for breeding

selección de las masas: la selección de plantas o animales ideales para servir como progenitores para la procreación

mutation: a change in genetic makeup of a DNA strand

mutación: un cambio en la configuración genética de una molécula de DNA

organism: a complete and entire living thing

organismo: un ente viviente completo

pedigree: genetic history of an organism

genealogía: la historia genética de un organismo

recessive characteristic: a characteristic that is masked by the dominant characteristic

característica recesiva: una característica que es encubierta por una característica dominante

RNA: a product of DNA, which controls certain cell activities, including protein synthesis

RNA: un producto del DNA el cual controla ciertas actividades celulares, incluyendo la síntesis de las proteinas

species: a group of organisms that can interbreed with each other and produce fertile young

trait: a distinguishing characteristic

vestigial organs: organs which no longer have a function and are poorly developed.

X chromosome: a sex chromosome present singly in human males and as a pair in females

Y chromosome: a sex chromosome found only in males

especies: un grupo de organismos que peuden procreasrse entre sí y cuyas crias son fértiles

rasgo: una característica distintiva

órganos degenerados: órganos que ya no pueden funcionar y los cuales se desarrollan pobremente

cromosoma X: un cromosoma que determina el sexo. En el hombre es sólo uno y en la mujer está presente en pares

cromosoma Y: un cromosoma que determina el sexo y el cual está presente sólo en el hombre

INVITATION 1

PEAS IN A POD

CONCEPTS

- **Some characteristics are inherited, some are not.**
- There is a reliable way to transfer information from one generation to another.

BACKGROUND

Gregor Mendel's contribution to the field of genetics evolved from his study of pea plants. He noticed that the pea plants varied in height. Some had yellow seeds, some green. The seven traits he studied were: stem length, flower position, seed shape, seed color, seed coat color, pod shape, and pod color. Most of his experiments were aimed at trying to determine how these traits were passed on. Mendel noticed that generation after generation tall pea plants always produced tall plants. Yellow seeds always produced yellow seeds. Eventually he discovered that tall plants crossed with short plants produced tall plants, but in the second generation 1/4 of the plants produced were short plants.

MATERIALS

- peas in pods
- copies of observation sheets, pages 8 or 9
- newsprint
- rulers
- balances
- white glue or double-sided sticky tape

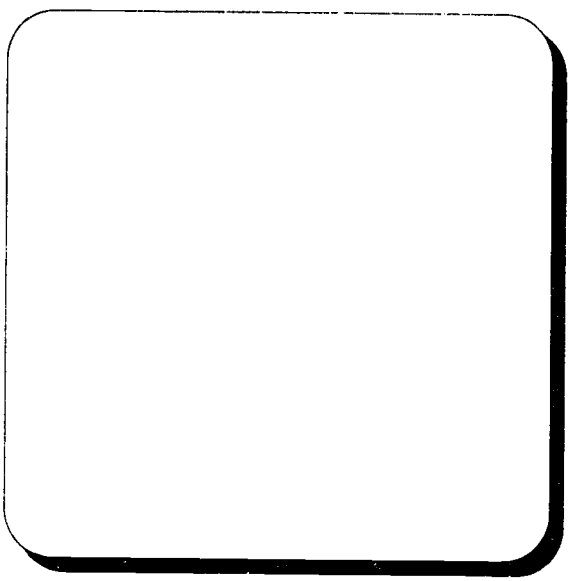
PROCEDURE

1. Give each student a pea pod. Record observations on observation sheet, pages 8 or 9.
2. Invite students to open the pods carefully and record observations.
3. Carefully remove each pea. As each pea is removed, weigh it, measure it and glue to observation sheet. Double sided tape will also work. It is important to keep peas identified and labeled. What is the same about all the peas? How do they differ?
4. In groups of 3-5, have students compare peas with other group members. On newsprint list similarities and differences.
5. In journals reflect on how all the peas in the class are like children in the classroom.
6. What makes a pea, a pea, and not a carrot or a cat?
7. What characteristics of the peas were inherited? What characteristics were not inherited?

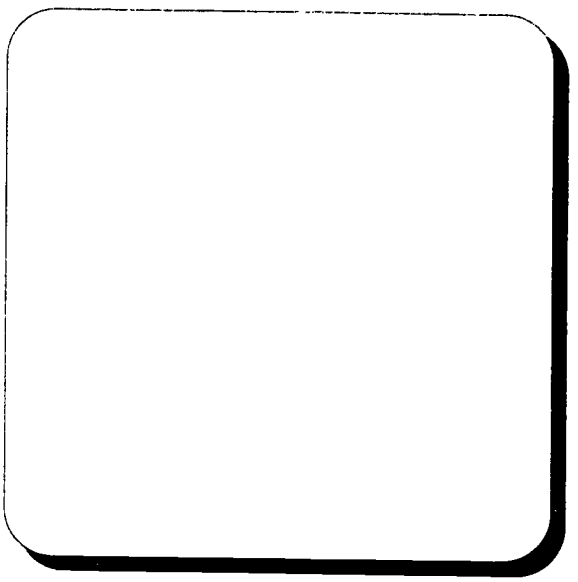
EXTENSION ACTIVITIES

- Repeat process with a litter of kittens or pictures of a litter of kittens or with flowers from the same stalk or branch.

PEAS IN A POD OBSERVATION SHEET



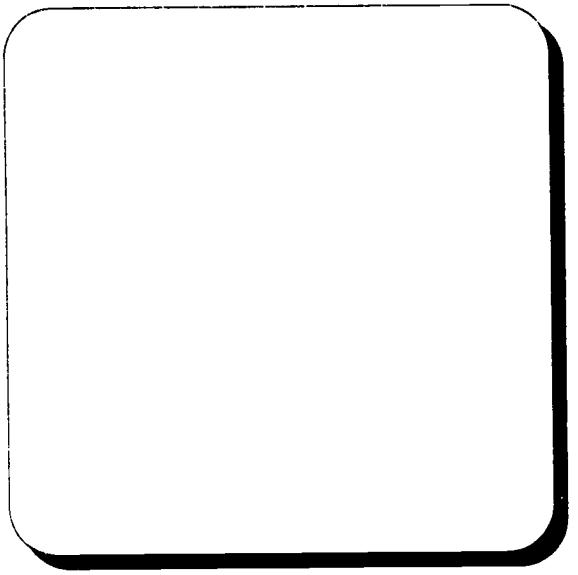
Draw a picture of the closed pea pod.



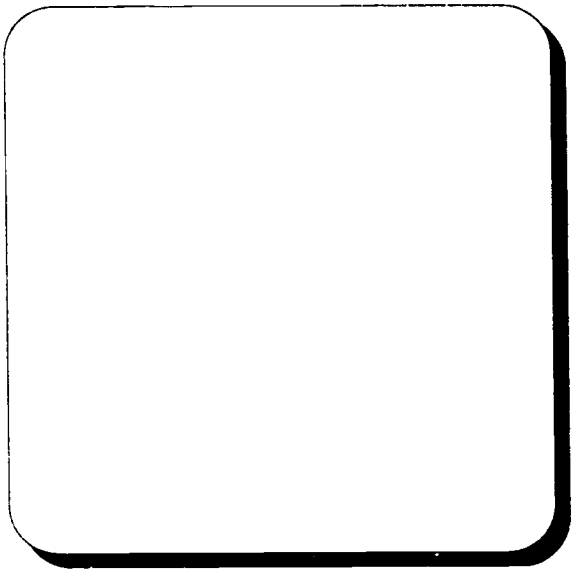
Draw picture of the open pea pod.

	Pea	Color	Size	Weight	Other observations
1					
2					
3					
4					
5					

HOJA DE OBSERVACIONES DE LOS GUISANTES EN SU VAINA



Dibuje una ilustración de la vaina de guisantes cerrada



Dibuje una ilustración de la vaina de guisantes abierta

	Guisante	Color	Tamano	Peso	Otras observaciones
1					
2					
3					
4					
5					

INVITATION 2

INHERITED OR LEARNED?

CONCEPTS

- **Some characteristics are inherited, some are not.**
- There is a reliable way to transfer information from one generation to another.

BACKGROUND

There are two primary influences acting together throughout one's life—heredity and environment. Heredity is the passing on of traits from one generation to the next. Environment includes all of the other forces that act on an organism.

It is difficult to tell in many case where the effects of heredity and those of environment begin and end.

A species is a group of organisms that resemble one another and are potentially able to breed with each other. In many ways, members of a species are alike. They carry genes for certain traits called specie traits. Walking erect is a species trait for human beings.

Individual traits cause members of a given species to be different from each other. Such traits include hair and eye color.

You may want to begin this invitation with a discussion about the various kinds of families that exist. Genetic traits are passed on from generation to generation. Biological fathers, mothers and siblings may not be present in a family grouping. Affirm the variety and kinds of families that exist in your classroom. A child may be living in a family where one or both parents are not biologically related to the child. Issues around who is really my mother or father may become very confusing especially if there is little understanding about sexual reproduction.

Children who live in family structures that do not include biological parents may provide opportunities to further explore traits that are inherited vs. traits that are learned. Often an adopted child will be told, "You look just like your mother, father, sibling." What does that imply about inherited and learned traits?

MATERIALS

- newsprint
- copies of pages 12 or 13

PROCEDURE

1. Divide a sheet of newsprint into two columns. Label columns: *Species Traits* and *Not Sure*. Brainstorm a list of traits and characteristics that distinguish humans from most other species, for example, walking upright. NOTE: The lines of differentiation between organisms that are closely related is difficult. It is all right to put traits in the *Not Sure* category. Creating this list may also lead into some sensitive areas. For example, while it is generally accepted that a species trait for human beings is walking erect, there are many human beings that cannot walk erect. It is important to help students appreciate the diversity that exists within the species.
2. Divide another piece of newsprint into two columns. Label columns: *Inherited Traits* and *Non-inherited Traits.*
3. Brainstorm a list of traits and characteristics of human beings for each column. This is a very difficult task. The goal is not to get perfectly correct lists, but rather to generate a discussion about issues related to inherited and learned traits and characteristics.
4. In journals reflect on the following questions or use pages 12 or 13. What characteristics or

traits do I possess? Which of these are species traits, inherited traits, or learned traits?

EXTENSION ACTIVITIES

- Have a debate about whether nature (inherited) or nurture (environment) is the most important influence affecting human beings.

INHERITED OR LEARNED?

List traits and characteristics that are true about you in the appropriate columns below.

Species Trait	Inherited Trait	Learned Trait

¿HEREDADO O APRENDIDO?

En las columnas que siguen a continuación, enumera rasgos y características de tí mismo.

Razgos de la especie	Razgos heredados	Razgos aprendidos

INVITATION 3

PASS IT ON

CONCEPTS

- **Some characteristics are inherited, some are not.**
- There is a reliable way to transfer information from one generation another.

BACKGROUND

Genetics is the science concerned with heredity and variation. Through analysis geneticists account for similarities and differences from one generation to the next.

A dominant characteristic is one that always appears in the first generation of offspring. Recessive characteristics rarely appear in the first generation. Only one dominant gene is needed for the trait to appear. But two recessive genes are needed for a recessive trait to appear.

MATERIALS

- set of at least 12 actual color photographs of individuals, include siblings, cousins, parents, and if possible twins. Label pictures 1-12. NOTE: Mounting pictures on stiff cardboard and covering with plastic wrap will protect the photographs.
- copies of pages 15 or 16

PROCEDURE

1. Display pictures on bulletin board or in Invitations Center.
2. In pairs have students decide which pictures represent people who might be genetically related, people who might be siblings or cousins or parents and offspring, recording decisions on page 15 or 16.
3. In journals invite students to list the criteria they used for making their decisions.
4. As a class, decide which pictures represent people who appear to be genetically related. Encourage students to state the criteria they used to make the determination. Allow time for debate. If students disagree help them justify their suggestions based on criteria.
5. Work toward a class consensus. While there is a "right" answer in this Invitation, it is not as important for students to "get the right answer" as it is for them to struggle for consensus based on some set of criteria. Students may decide that two people are siblings because they are wearing the same kind of clothing. Do not discourage these suggestions, but during the following discussion help students continue to differentiate between characteristics that are inherited and those that are not.
6. After sufficient discussion and debate arrange pictures in actual genetic groupings. Discuss similarities and differences between genetically related people. In what ways did the class's list match the real case? Discuss traits that made it possible.

EXTENSION ACTIVITIES

- Make a bulletin board entitled *The Same Yet Different*. Have students bring in pictures of family members for the bulletin board. Or make a bulletin board entitled *Humans--One Species Many Differences*. Have students find pictures in magazines for the bulletin board. Encourage diversity.
- Research contributions of Francesco Redi to the field of heredity.

PASS IT ON

The person in the following photograph	is genetically related to the following people
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	

The criteria I used to make these determinations . . .

PÁSALO

La persona en la fotografía que sigue	está genéticamente relacionada a las siguientes personas
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	

Las especificaciones que utilicé para tomar estas decisiones . . .

INVITATION 4

POPULATION SAMPLING

CONCEPTS

- **Some characteristics are inherited, some are not.**
- There is a reliable way to transfer information from one generation to another.

BACKGROUND

People have many inherited traits: some can be seen, some can not. Some traits are classified as dominant, some as recessive. For example, freckles and dimples are caused by dominant genes. Attached earlobes are recessive traits. Even if both parents have detached earlobes, it is still possible for the offspring to have the recessive trait because each parent could be carrying the recessive gene.

This invitation involves gathering data on the following traits:

- widow's peak—hairline that comes down to a peak in the middle of the forehead
- freckles—small reddish brown spots on the skin
- attached earlobes—tips of earlobes completely attached to the side of the head
- cleft chin—indentation in the middle of the chin
- dimples—small indentations in the cheeks
- tongue rolling—ability to roll the edges of the tongue up on each side.

MATERIALS

- Copies of pages 18 or 19

PROCEDURE

1. Invite students to fill out column 1 page 18 or 19 about themselves.
2. Help students pool data from the class and record information in column 2.
3. Help students calculate % of students in the class with each trait. Fill in column 3.
4. Devise a method for collecting data from another class, several classes, the whole school. This part of the activity will depend on the flexibility of your colleagues and your school setting. If it is possible have pairs of students go to other classrooms and count the number of people in each category.
5. Record pooled data in column 4 and calculate % of total population in each category. Record in column 5.
6. From data have students speculate whether the traits are dominant or recessive.
7. How do these results compare to currently held theories about these traits?

EXTENSION ACTIVITIES

- Invite an animal breeder to discuss the process of breeding animals for certain characteristics and traits.
- Research other characteristics and traits that can be identified as dominant and recessive.
- Have students identify traits in their extended families and calculate the percentages of total family members sampled with class or school percentages.

POPULATION SAMPLING

Trait	Me Check if true for you.	Number of class members with trait	% of class members with trait	Number of people in larger sample with trait	% of larger sample with trait
Widow's Peak					
Freckles					
Attached earlobes					
Cleft chin					
Dimples					
Tongue rolling					

MUESTRA DE UNA POBLACIÓN

Razgos	**Los míos** **Asegúrate de que sean ciertos en tu caso**	**Número de miembros en la clase con este razgo**	**% de miembros en la clase que comparten esta característica**	**Número de personas en la meustra más grand con este razgo**	**% de la muestra más grande con este razgo**
Cabello en cresta					
Pecas					
Orejas pegadas					
Barbilla hendida					
Hoyeulos					
Lengua curva					

INVITATION 5

CORN GENES

CONCEPTS

- **Some characteristics are inherited, some are not.**
- There is a reliable way to transfer information from one generation to another.

BACKGROUND

Corn seeds that germinate will have either green or white leaves. Not all corn seeds have the genes for green leaves. Because all the seeds look alike, we cannot tell which genes they have until they germinate. Corn plants that remain white several days after sprouting have the albino trait. Because these plants are missing chlorophyll and cannot make food, they soon die.

MATERIALS

- at least 20 corn seeds for each student or pair of student
- paper towels
- small plastic dishes (from TV dinners)
- water
- copies of pages 21 or 22

PROCEDURE

1. Observe the seeds carefully. Ask students to predict which seeds will grow into green plants and which will grow into white plants
2. Place folded, moistened towel in the bottom of the dish.
3. Place the seeds on the towel.
4. Cover the dish.
5. Place the dish under a light and keep watered.
6. Observe the seeds each day recording observations. Continue observations until all seeds have sprouted.
7. In journals, reflect on the following questions. Is there any way to tell ahead of time which seeds would produce green leaves? Why don't the plants with white leaves live as long as plants with green leaves. Why do you think most plants in fields and forests are green?

EXTENSION ACTIVITIES

- Invite a farmer to discuss how different strains of vegetables or animals are created.
- Have a debate about the positives and negatives of genetic engineering.

CORN GENES

	Number of Corn Seeds Sprouted	Number with green leaves	% of green leaves	Number with white leaves	% of white leaves	Other Observations
Day 1						
Day 2						
Day 3						
Day 4						
Day 5						
Day 6						
Day 7						
Day 8						
Day 9						
Day 10						
Day 11						
Day 12						
Day 13						
Day 14						
Day 15						
Day 16						
Day 17						
Day 20						
Total						

GENES DEL MAÍZ

	Número de cemillas de maíz que germinaron	Número de hojas verdes	% de hojas	Número de hojas	% de hojas blancas	Otras observaciones
Día 1						
Día 2						
Día 3						
Día 4						
Día 5						
Día 6						
Día 7						
Día 8						
Día 9						
Día 10						
Día 11						
Día 12						
Día 13						
Día 14						
Día 15						
Día 16						
Día 17						
Día 20						
Total						

INVITATION 6

CODE-BREAKER

CONCEPTS

- Some characteristics are inherited, some are not.
- **There is a reliable way to transfer information from one generation to another.**

BACKGROUND

The process scientists used to break the DNA code is similar to the process any code-breaker or cryptographer goes through. It took many years for scientists to finally break the DNA code.

In the study of cryptography, the coded message is called a cryptogram from two Greek words, kryptos meaning *hidden*, and gamma meaning *a writing*. A person who writes and decodes secret messages is a cryptographer.

One type of code is locked in our genes. These genes control the way that we appear. The entire code that controls our appearance is made up of only four nucleotides.

While breaking codes is fun, it is only part of the process. In this invitation it is important for students to analyze and understand the process they used to break the code. In this way they will get a sense of the process biologists and geneticists used to come to understand how DNA worked to pass on traits.

MATERIALS

- sample codes and messages page 25 or 26
- copies of page 27 or 28

PROCEDURE

1. Give students copies of coded messages on pages 25 or 26
2. Have them try to break the code for message #1.
3. In journals have students describe the different processes they tried for breaking the code. (Some students will use a random approach.) Invite students to describe the different approaches. As processes are described, list on board or newsprint. After most students have contributed possibilities to the list, circle the process that actually worked to break the code. Help students to understand the steps involved.
4. Invite students to try to decode message #2 using the rules established for decoding message #1.
5. After a short period of time, students may realize that a different set of rules is needed to decode message two. In journals, reflect on how the process worked or didn't work.
6. Divide the class into groups of 3-4. Have groups try to decode the message using some of the processes listed on board. If none of these work, have students try to discover the processes for decoding the message.
7. Reflect in journals on what they tried, why they tried what they tried, what worked, what didn't work.
8. Regroup students. Invite students to decode message #3 using what they learned from trying to decode messages #1 and #2.
9. After each journal reflection time, help students to explain their processes. Record any new processes on list started in step #3.

10. Have each student create a coded message. Be sure students keep a copy of the original coded message safely hidden. The teacher may want to keep the original messages for safe keeping.
11. **NOTE:** For the next part of this activity the students will decode each other's messages. It is important for the students to try to decode as many messages as possible. Here are some alternatives:

    A. Put all coded messages in the *Invitation Center*. Allow students 3-4 days to go to the center and decode as many messages as possible, keeping track of which messages were which. Pages 27 or 28 may help.

    B. Collect coded messages, transfer student's coded messages into column 1. Make copies and redistribute to class.

    Remember that it is more important to analyze the process for breaking the code, than to get the *right* answer.
12. In journals reflect on which kinds of codes were easy to break, which difficult to break. Why?

EXTENSION ACTIVITIES

- Have students locate articles related to genes or genetic engineering in current magazines (*Time, Newsweek*) or newspapers .
- Invite a geneticist to class

For Teacher's Information:

Messages Decoded

1. Some traits are inherited, some are not.
2. Working together is fun.
3. I never thought I would figure this out.
1. Algunos rozgos son heredados, otros no.
2. Trabajar en grupo es divertido.
3. Yo nunca pensé que podría decodificar estos mensajes.

CODE-BREAKER

Message #1

Tpnf usbjut bf hoifsjufe, tpnf bsf opu.

Steps I used to try to decode this message.

Message #2

011 111 010 101 00 10 110 1 111 110 0 1 0000 0 010 00 000 0010 001 10.

Steps we used to try to decode this message

Message #3

♓ ■♏❖♏□ ♦♒□◆♑♒♦ ♓ ♦□◆●♎ ♐♓♑◆□♏ ♦♒♓♦ □◆♦

Steps we used to try to decode this message.

DECODIFICANDO LOS MENSAJES

Mensaje #1

Bmhvopt sbahpt tpo ifsfebept, puspt op.

Pasos que seguí para tratar de decodificar este mensage.

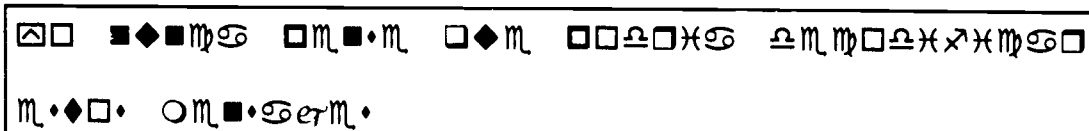
Mensaje #2

1 010 01 1000 01 0111 01 010 0 10 110 010 001 0110 111 0 000

100 00 0001 0 010 1 00 100 111.

Pasos que seguimos para tratar de decodificar este mensaje.

Mensaje #3



Pasos que seguimos para tratar de decodificar este mensaje.

CODE-BREAKER 2

For each message below, describe steps you tried to decode the message.

Message	Steps used to decode message

DECODIFICANDO LOS MENSAJES

Para cada mensaje que sigue describe los pasos que utilizaste para de codificarlos.

Mensaje	Pasos para decodificar el mensaje

INVITATION 7

ALPHABET SOUP

CONCEPTS

- Some characteristics are inherited, some are not.
- **There is a reliable way to transfer information from one generation to another.**

BACKGROUND

DNA is present in all forms of life. DNA makes up genes, controls traits, forms chromosomes, and is found in the nucleus. Except for a few viruses its function and structure are always the same. DNA is made from only four different sugars, but is able to make 5 billion people in the world, none of whom are the same. It is amazing to realize that all the inherited traits that make us who we are, are made from a variety of combinations of only four different sugars.

NOTE: This invitation is best done in conjunction with and after Invitation 6.

MATERIALS

- a set of letters for each student, one each of the following letters: T, A, G, C. (Students can be told that scientists presently believe that there are only 4 sugars that make up the parts of DNA responsible for coding the traits. Scientists labeled these sugars with the letters T, A, G, and C.)

PROCEDURE

1. Give each student one set of letters. Invite students to make as many different combinations as possible using only the 4 letters. The letters do not need to form a recognizable word. Students will need to devise some way to keep track. Students must use all four letters.
2. Combine student's contributions into one list.
3. Pair students. Using both students' sets of letters make as many different combinations of letters as possible. Encourage students to develop a system for keeping track of all the combinations.
4. You may want to try groups of four students. It soon becomes impossible to keep track of all the possibilities.
5. Explain that message #2 from the previous invitation uses only two symbols, yet these two symbols can be put together to form words and sentences. Help students appreciate the fact that many combinations can be created by using only 4 different letters. Help them imagine that each different combination is a code for a unique trait.

INVITATION 8

SUPER SLEUTH

CONCEPTS

- Some characteristics are inherited, some are not.
- There is a reliable way to transfer information from one generation to another.

BACKGROUND

Some traits are inherited, some are not. Everyone has fingerprints, and these fingerprints are unique to each person. It doesn't matter what your parent's fingerprints are. As no two snowflakes are the same, there are no two finger prints that are the same either. Finger prints cannot be changed.

MATERIALS

- non-toxic black ink stamp pad
- rubbing alcohol
- paper towels
- copies of fingerprinting record on pages 31 or 32
- magnifying glass
- roll of 1 inch wide clear, sticky tape
- small watercolor brush
- charcoal powder

PROCEDURE

1. Make copies of the fingerprint record sheet for each student.
2. Have students wash and dry their hands.
3. Make rolled impressions of each finger or thumb, by inking each one at a time, and rolling each finger and thumb onto paper.
4. Make plain impressions, by inking the four fingers of the hand and printing them together. Press the fingers flat against the paper. Do not roll them. Ink thumb and press it flat against the paper. Display prints.
5. To remove the ink, use a little rubbing alcohol and a paper towel.
6. Locate an area in the room where there will be fingerprints. Windows, mirrors, and glasses are good sources.
7. Use a watercolor brush to carefully dust the charcoal powder onto the print.
8. Using a piece of tape, carefully press it onto the dusted print. Make sure to cover the print smoothly. Lift the print. Try to identify whose print it is by comparing it to the prints of the class.

EXTENSION ACTIVITIES

- After printing the entire class, stage a mock crime scene. Have the students lift the prints around the room to solve the crime.

FINGERPRINTS

Name:
Address:
Birthday:
Date printed:

RIGHT THUMB	RIGHT INDEX	RIGHT MIDDLE	RIGHT RING	RIGHT LITTLE
LEFT THUMB	LEFT INDEX	LEFT MIDDLE	LEFT RING	LEFT LITTLE

LEFT FOUR FINGERS	LEFT THUMB	RIGHT THUMB	RIGHT FOUR FINGERS

HUELLAS DIGITALES

Nombre:
Dirección:
Fecha de Nacimiento:
Fecha de toma:

PULGAR DERECHO	ÍNDICE DERECHO	CORDIAL DERECHO	ANULAR DERECHO	MEÑIQUE DERECHO
PULGAR IZQUIERDO	ÍNDICE IZQUIERDO	CORDIAL IZQUIERDO	ANULAR IZQUIERDO	MEÑIQUE IZQUIERDO

CUATRO DEDOS DE LA MANO IZQUIERDA	PULGAR IZQUIERDO	PULGAR DERECHO	CUATRO DEDOS DE LA MANO DERECHA

INVITATION 9

DNA FINGERPRINTS

CONCEPTS

- Some characteristics are inherited, some are not.
- There is a reliable way to transfer information from one generation to another.

BACKGROUND

Just as every human being has finger prints that are unique, every human being has a DNA pattern that is unique. Scientists estimate that the chances of two human beings having the identical DNA pattern is approximately 30 billion to 1. Short segments of an individual's DNA are analyzed for the pattern. DNA fragments are treated with a radioactive substance that produces a pattern of stripes when exposed to x-ray film. The pattern created is unique for every human being. The patterns created resemble bar codes. These segments are sorted and categorized.

The DNA pattern is the same for each cell in the body. Therefore, a person's DNA pattern can be determined from a strand of hair, a drop of blood, or any cell of the body. DNA fingerprints have become popular recently in solving violent crimes.

MATERIALS

- a set of bar codes from everyday products, with at least two of each one. Remove any other identifying information, i.e. numbers or brands. Label each bar code for your information. For younger children, you may want to enlarge the bar codes.
- copies of page 34 or 35.

PROCEDURE

Depending on your tolerance for chaos, the following can be accomplished either way.

Chaos method.

1. Give each student a bar code. Let them find their partners at will by matching bar codes. Go to step #2 below.

Less chaos.

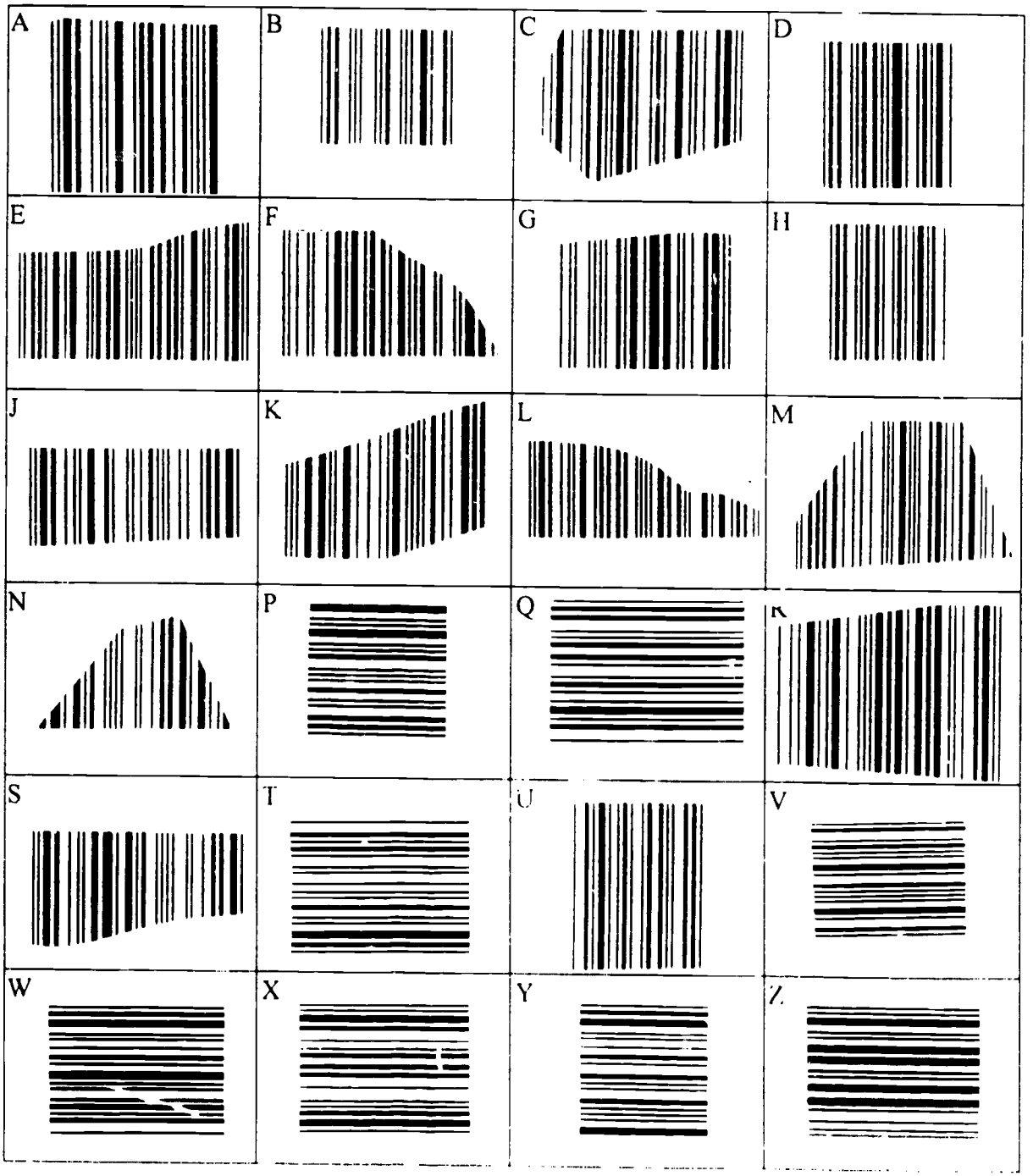
1. Give each student a bar code. Select one student to find all of their partners by matching bar codes. Select another student to find their partners, etc.
2. Explain to students that police often use DNA codes to find criminals.
3. Give each student a copy of page 34 or 35. Invite them to find the criminal. **NOTE:** G and S most nearly match.

EXTENSION ACTIVITIES

1. Discuss other ways in which DNA finger printing can be used.

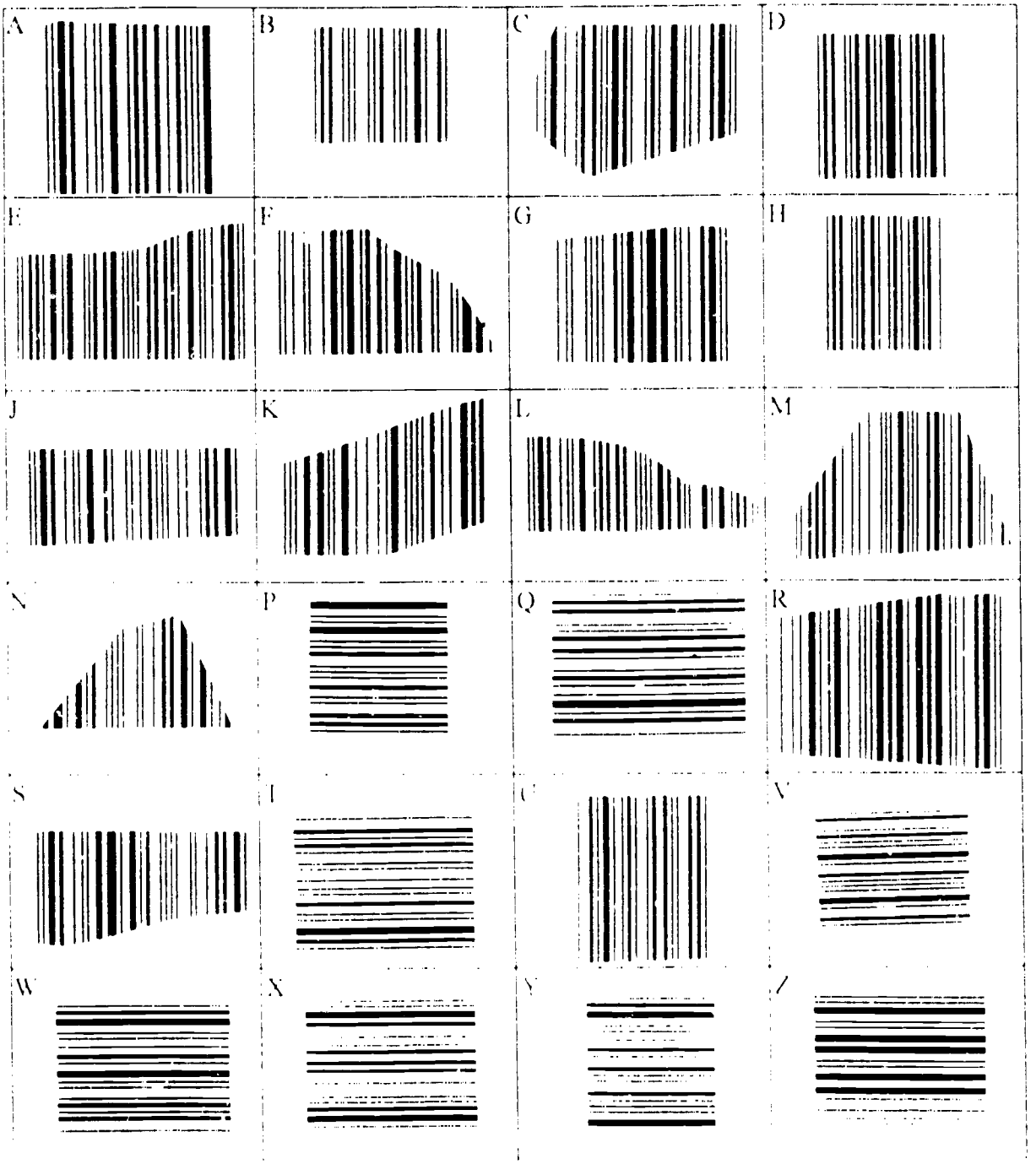
DNA FINGERPRINTS

Identify the criminal by finding the DNA print that matches the DNA found at the scene of the crime. Unfortunately, the DNA prints got mixed up in the lab. You can identify the possible criminal by finding two DNA prints that match perfectly.



DNA HUELLAS DIGITALES

Identifica al delincuente encontrando la muestra de DNA igual a la muestra de DNA hallanda en la escena del crimen. Desgraciadamente la muestra de DNA mezeló con otras muestras en el laboratorio. Puedes identificar al posible delincuente escogiendo dos muestras de DNA que se igualan perfectamente.



INVITATION 10

CHIMERA

CONCEPTS

- Some characteristics are inherited, some are not.
- **There is a reliable way to transfer information from one generation to another.**

BACKGROUND

In Greek mythology a chimera is a fire-breathing monster usually represented as a composite of a lion, goat, and serpent. In genetics, a chimera is an organism consisting of two or more tissues of different genetic composition, produced as a result of mutation, grafting, or the mixture of cell populations. It is also an organism produced by genetic engineering, in which DNA from distinct parent species is combined to produce an individual with a double chromosome complement.

Throughout history, humans have bred animals and plants, searching for the best suited organism for a given purpose. For example, chickens are bred either for egg production or for meat production, rarely for both. Cows are bred for milk production or meat production. Mules are bred to do heavy work.

Often a strain of vegetable will originate from a mutation and then be cultivated for production, such as: navel oranges, Delicious apples, seedless grapes, and pink grapefruit.

Amaranth, a grain used by the Aztecs, with a particularly high protein content is being cultivated now as a possible source of protein for undernourished population.

With the advent of genetic engineering it becomes more possible to create strains of plants and animals that were unheard of decades ago.

MATERIALS

- a variety of myths from many cultures that show examples of chimera.
- arts and crafts supplies
- a variety of fruits and vegetables that were encouraged to develop by human beings, i.e. nectarines
- animals or pictures of animals that have been bred for specific purposes.

PROCEDURE

1. Read stories to students or have students read a variety of stories about chimera.
2. Invite students to write a story about a chimera that they create. Encourage students to be intentional about the traits they select to include in the organism. Green antenna are fine if they have a real function.
3. Invite students to create their fictional organism (animal and plant) with the arts and crafts supplies.
4. Discuss the issues involved in breeding plants and animals for specific traits.
5. Invite students to design a plant that will contribute to the elimination of hunger in the world. What traits will they select from what kind of plants? Do you need different traits depending on the environment and climate? You may want to divide students into groups based on climate, i.e., desert, tundra, jungle, New York City, etc. Each group can design a plant for that specific environment.
6. Have a debate: Genetic Engineering--helpful or harmful?

EXTENSION ACTIVITIES

- Have students research genetic disorders, such as: cystic fibrosis, muscular dystrophy, dyslexia, color blindness, sickle-cell anemia, Tay-sachs.
- Have a debate about the ethics and implications of DNA libraries

APPENDIX A

The following list includes people that have contributed to the field of genetics and heredity.

1871	Fredrich Mishcher
1871	Luther Burbank
1902	Walter Sutton
1903	Phoebus Levine
1908	A. E. Garrod
1910	Thomas Hunt Morgan
1914	Robert Fuelgen
1928	Fred Griffith
1941	George Beadle
1941	Edward Tatum
1944	Oswald Avery
1944	Maclyn McCarty
1944	Colin MacLeod
1947	Erwin Chargoff
1949	Linus Pauling
1951	Maurice Wilkins
1951	Rosalind Franklin
1952	Alfred Hershey
1952	Margaret Chase
1953	James Watson
1953	Francis Crick
1961	Marshall Nirenberg
1961	J. H. Matther
1961	Severo Ochoa
1971	Marie Maynard Daly
1972	Paul Berg
1972	Stanley Cohen
1972	Herbert Boyer
1975	F. Agnes Stroud-Lee
1983	Barbara McClintock
1987	Susamu Tanegawa
1988	James Watson
1992	Mark Dubarch

MY

SCIENCE

JOURNAL

Scientist's Name_____

MI

CUADERNO

DE

CIENCIA

Nombre del Científico_____

Journal Thoughts and Ideas

Invitation_____

Books I've read on this topic

Today I learned

Cuaderno de Ideas
Sugerencias_____

Libros que he leído sobre este tema.

Aprendí hoy . .

NOTES